Proceedings of the 4th International Conference on Machine Learning and Automation
DOI: 10.54254/2755-2721/2026.39081

Application and Technical Framework of Large Language Model in Sports Fitness Scene

Xinyi Yang

College of Robotics and Artificial Intelligence, Hunan University, Changsha, China
yangxinyi0930@163.com

Abstract. Large language models deliver strong performance in understanding natural language, generating knowledge content and sustaining multi-turn conversations, opening new technical possibilities for digital transformation within sports and fitness industries. This paper first sorts out two core technical components of such models: pre-training and fine-tuning. Drawing on existing published studies and real-world product cases, it investigates several typical usage scenarios, including fitness knowledge Q&A, custom exercise plan generation, AI-based virtual coaching, and psychological intervention for exercisers. Apart from summarizing the practical strengths brought by large-language-model-driven fitness services, this review also points out multiple tangible obstacles in real-world application. These include model-induced knowledge hallucination, insufficient high-quality datasets built for vertical fitness domains, unsatisfactory multimodal integration effects, as well as unsettled issues around user privacy protection and liability division. Corresponding countermeasures are discussed from five practical dimensions: domain dataset construction, targeted model optimization, multimodal technical upgrading, privacy risk control and industrial standard-setting. It should be noted that most current research remains at the exploratory phase, and real-user-based empirical evidence is still limited. This work hopes to offer usable references for follow-up academic research and actual product deployment of large language models applied in sports-fitness vertical domains.

Keywords: Large language model, Sports and fitness, Pre-trained model, Personalized fitness, Multimodal integration

1. Introduction

In recent years, the public's fitness demands have grown more diversified. More people begin to attach importance to personal physical health, and ordinary fitness enthusiasts hope to obtain scientific exercise guidance and training arrangements matching their own conditions. Traditional fitness services mostly rely on offline coaches, yet high-quality coaching resources are often limited by geography, service cost and time costs, making professional guidance hard to reach most ordinary users. As large language models keep updating iteratively, artificial intelligence techniques have expanded beyond general text generation and penetrated vertical sectors such as healthcare, education and sports. This trend provides new ideas to ease the shortage of accessible fitness guidance resources.

© 2026 The Authors. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

DOI: 10.54254/2755-2721/2026.39081

Large language models can produce individualized workout schemes after processing user input information and combining users' physical status as well as fitness targets. When cooperating with multimodal techniques, these models are able to accept motion video streams and physiological signals collected by wearable devices, so as to build interactive intelligent fitness service modes. Even so, mainstream general-purpose large language models have not undergone special training oriented toward sports-fitness domains. Defects still exist in the precision of professional sports knowledge output, safety level of exercise prescriptions and human physical state perception. Direct deployment in fitness scenarios may trigger negative consequences such as wrong factual statements and sports injuries among exercisers.

Lots of research projects and commercial products have tried applying large language models to fitness fields. Song Wei and collaborators constructed special knowledge bases for sports and fitness. By adopting the Chroma vector database, BGE embedding model, LangChain framework and quantized large causal language models, their system realized fast semantic retrieval and effective logical reasoning at millisecond-level response speed [1]. Aiming at defects of conventional sports training driven mainly by practical experience — including poor individual adaptability and low-efficiency data fusion — Haowenbin and his team analyzed application potential, technical merits and real-world limitations of multimodal tools and large language models in competitive sports training and mass fitness practice [2]. Through a series of system performance tests, Wang Runfeng explored how large language models perform in sports-related tasks, discussed their application value for physical education, and laid groundwork for further research in this field [3]. Nevertheless, few existing papers deliver comprehensive reviews covering technical frameworks, application status, practical bottlenecks and coping strategies. Given the above research gap, this paper conducts a systematic review from technical foundation, typical application scenarios, realistic challenges and feasible countermeasures. It explains how large language models work when serving fitness businesses, evaluates merits and deficiencies of current applications, and delivers theoretical references for follow-up research and product development, which carries practical research significance.

2. Core technical foundations of large language models

2.1. Core concept definition and key technology overview

2.1.1. Large language model (LLM)

Large language models are built on the Transformer architecture and pre-trained using massive text corpora. They possess multiple core capabilities: natural language comprehension, text generation, logical reasoning, knowledge-based question answering and multi-round conversation. Such models receive natural-language input from human users and produce logically reasonable replies. Their representative strengths include storing abundant general knowledge, maintaining context in multi-turn dialogue, and finishing complex tasks such as text summarization, paraphrasing and solution drafting.

2.1.2. Pre-training technology

Pre-trained models obtain basic language capabilities after learning from large-scale unlabeled text data. Such pre-training work forms the foundation for subsequent adaptation toward various downstream practical tasks.

DOI: 10.54254/2755-2721/2026.39081

2.1.3. Fine-tuning technology

Fine-tuning means further model training with task-specific datasets on top of pre-trained weights, so that models can adapt to targeted downstream scenarios. Lightweight fine-tuning approaches represented by LoRA only adjust partial model parameters instead of the whole weight set. Such methods greatly cut computational resource consumption and lower deployment costs for practical usage.

2.1.4. Natural language understanding and generation

Natural language understanding allows models to figure out user intention from unstructured natural-language input. Natural language generation helps models output coherent text matching task requirements. Together they constitute the basic support for interactive fitness guidance services.

2.1.5. Context-aware multi-turn dialogue technology

Context-aware multi-turn dialogue mechanisms reserve information from previous conversation rounds. During long-term fitness interaction, models can continuously track users' physical changes and shifting fitness needs.

2.2. Technical adaptation of large language models for sports and fitness scenarios

2.2.1. Limitations of direct deployment of general-purpose large language models

Although commercial large language models have relatively mature workflow systems, simply putting them into sports-fitness scenarios will bring obvious drawbacks. First, without domain-oriented professional training, general-purpose models tend to generate hallucinated content on topics like sports anatomy, injury rehabilitation and exercise prescriptions; misleading outputs may even cause physical injuries for exercisers. Second, general models cannot directly read physiological signals or motion data. They can only receive text-based descriptions manually provided by users, which results in insufficient perception of users' real physical conditions. Third, these models lack scenario-specific safety constraints and fitness-oriented risk warning modules. Therefore, targeted modification is indispensable before general large models can be safely used for high-risk fitness-related work.

2.2.2. Technical adaptation approaches oriented to sports and fitness

To fit sports-fitness scenarios, large language models need targeted technical adjustment. Researchers can conduct instruction-based lightweight fine-tuning with high-quality domain datasets, so as to improve the professional level of model outputs. Retrieval-augmented generation (RAG) can be introduced to restrict model responses with verified domain knowledge bases and reduce knowledge hallucination risks. Besides, multimodal interfaces need to be built, which import motion recognition outcomes and wearable physiological data, and convert heterogeneous sensing information into readable input formats for models. Safety control modules should also be embedded: they identify high-risk suggestions and attach necessary risk disclaimers, so as to achieve safe fitness services supported by domain-adapted large language models.

DOI: 10.54254/2755-2721/2026.39081

3. Application scenarios, commercial cases and academic research status of large language models in sports and fitness

3.1. Typical application scenarios

3.1.1. Intelligent fitness knowledge question-and-answering

Intelligent Q&A for fitness knowledge stands as the most basic application form of large language models within fitness fields. Users raise questions about exercise principles, nutritional intake and injury prevention through natural-language conversation. Combined with domain knowledge bases, models return targeted, science-supported popular-science content, lowering knowledge-acquisition barriers for ordinary fitness crowds.

3.1.2. Personalized exercise prescription generation

After collecting user information including age, gender, physical status, injury history, available exercise facilities and fitness goals, large language models generate customized training plans covering exercise types, training intensity, workout volume, training frequency and rest cycles, to satisfy differentiated fitness demands among different users.

3.1.3. AI-powered intelligent fitness coach

AI-driven virtual fitness coaches offer interactive guidance in the whole training process. Connected with multimodal sensing units, they spot incorrect movement postures, give corrective advice and dynamically adjust training intensity. To some extent, these virtual coaches can replace part of teaching work completed by offline human coaches [4].

3.1.4. Fitness-related psychological counseling and exercise motivation intervention

Lack of motivation and poor long-term adherence are major barriers keeping people from persistent fitness practice. Large language models can deliver psychological support, ease anxiety triggered by fitness pressure, strengthen users' willingness to work out, and help users stick to long-term exercise habits.

3.2. Review of commercial deployment cases

At present, many mainstream fitness applications have integrated large-model modules and launched AI fitness assistant functions, most of which support text-based Q&A and training-plan generation. For example, Keep has rolled out its AI fitness assistant. This function creates customized training schemes according to user profiles and answers fitness-related questions interactively. Fitbod also introduces large-model technologies to adjust strength training plans dynamically based on user feedback. Even so, existing commercial products still have obvious shortcomings. In most applications, large-model modules operate as independent plugins that cannot connect with motion recognition or wearable sensing systems; deep multimodal fusion has not been realized. AI-generated exercise prescriptions are seldom checked by sports-science experts, which brings hidden safety risks. Existing services mainly target general crowds, while special groups such as the elderly, chronic-disease patients and sports-injury rehabilitation users cannot get enough tailored support. Some AI fitness functions are only available for paying users, which limits their popularization.

DOI: 10.54254/2755-2721/2026.39081

From the perspective of development tendency, fitness software is transforming from pure text interaction to multimodal intelligent services driven by multi-source sensing data; risk-reminder mechanisms are also being gradually added into product designs [5].

3.3. Advantage analysis of large-language-model-enabled sports and fitness

3.3.1. Personalization advantages

Traditional fitness software mostly provides fixed, standardized training courses. By contrast, large language models analyze multi-dimensional user information and produce plans matching individual features, breaking the limitations brought by unified preset content [6].

3.3.2. Inclusiveness

Offline one-on-one coach services cost too much to serve large social groups. Fitness services built on large language models lower access thresholds for professional guidance and make up for the shortage of high-quality fitness resources among ordinary people.

3.3.3. Interaction convenience

Natural-language interaction reduces operation difficulty. Users can obtain guidance through conversational input without mastering complicated software operations, improving the usability of fitness services.

3.3.4. Multimodal expansion potential

Large language models work as core decision-making hubs. When connected with motion capture, computer vision and wearable physiological monitoring units, they help build closed-loop service chains covering perception, decision-making, guidance and feedback, showing huge development prospects [7].

3.4. Status of domestic academic research

Current domestic research about large language models for sports-fitness fields can be divided into three directions: constructing domain-specific intelligent Q&A systems, reliability evaluation for model-produced exercise prescriptions, and prospect analysis for multimodal application directions. Existing studies confirm that large language models have preliminary reasoning ability for sports-fitness knowledge. Meanwhile, researchers also observe prominent risks such as knowledge hallucination and unreliable workout suggestions. Most published papers remain at theoretical exploration stages; empirical research based on real-user data is relatively scarce. Studies concerning privacy governance, liability allocation and industrial regulatory rules for AI fitness products are still at an early stage. Sui Yong and co-workers assessed the practical value of large language models in exercise prescription formulation. They pointed out deficiencies in motion rhythm control and real-time feedback, yet did not put forward operable improvement solutions. Their research adopted simulated datasets rather than real-user verification, so experimental results cannot fully reflect users' actual physical features and movement conditions [8].

DOI: 10.54254/2755-2721/2026.39081

4. Realistic dilemmas and breakthrough pathways for large-language-model-empowered sports and fitness

4.1. Technical bottlenecks

First of all, knowledge reliability cannot be fully guaranteed. Due to the probabilistic generation mechanism of large language models, knowledge hallucination is hard to eliminate completely. Model outputs may look logically smooth but contain factual mistakes in sports anatomy, rehabilitation therapy and exercise prescription parameters. For injury consultation scenarios, wrong replies will raise exercisers' injury risk, which represents the most critical hidden safety problem.

Second, high-quality annotated fitness-domain datasets are insufficient. Samples targeting special crowds and sports-injury rehabilitation are particularly scarce. Plenty of public fitness resources online come from informal media sources with uneven content quality. Training data quality directly restricts model performance within vertical domains [8].

Third, fragmentation is common among commercial products. Large language models are often used as separate Q&A or plan-generation plugins. They fail to communicate with user profile systems, motion detection modules, physiological sensing tools and training-effect evaluation units, so complete end-to-end closed-loop services have not been formed.

Fourth, multimodal fusion depth is insufficient. For most products, motion-recognition outputs and wearable data are only displayed separately instead of being imported into large language models for decision analysis. Models still heavily reply on manually entered text information, lacking real-time perception of users' physical conditions.

4.2. Application-level and industrial-level practical challenges

To start with, user privacy and data security risks deserve wide attention. AI fitness platforms collect large volumes of sensitive personal health data. Imperfect protection for data storage and transmission may trigger privacy leakage; unauthorized access from third parties may also cause data misuse.

Moreover, liability attribution rules are ambiguous. If users suffer sports injuries caused by wrong AI-generated exercise prescriptions, current laws and industrial codes have not set clear standards to divide responsibilities among model developers, application operators and end users. Such uncertainty restricts large-scale product promotion [9].

In addition, adapting to real-user situations remains difficult. Present-day systems mainly depend on manual text input. Users can hardly describe injury severity or movement execution quality accurately. Without direct perception of real physical conditions, generated plans may mismatch individual needs. This situation calls for supplementary sensing capacity brought by multimodal technologies [10].

4.3. Breakthrough pathways for sports and fitness scenarios

4.3.1. Dataset construction

Researchers can cooperate with experts specialized in exercise physiology, sports rehabilitation and fitness practice to build domain-specific datasets. Q&A samples and exercise-prescription cases need expert verification, while low-quality fitness content spread online should be filtered out. Priority should be given to supplementing samples related to sports injury cases and special

DOI: 10.54254/2755-2721/2026.39081

population groups. Data quality audit mechanisms ought to be established, to reduce model output errors starting from the data source.

4.3.2. Model optimization

High-quality fitness-domain datasets can be used for LoRA-based instruction fine-tuning, to strengthen models' ability to produce professional content. Independent knowledge verification modules should be added to double-check AI-generated exercise prescriptions and rehabilitation advice. Safety guardrails need to be built to identify and block dangerous workout suggestions; mandatory risk disclaimers are also required.

4.3.3. Deepen multimodal integration

Camera-based motion recognition and intelligent wearable device interfaces should be adopted. Heart-rate information, movement standard evaluation indicators and training-load data will be converted into input data acceptable for models. A complete closed-loop workflow should be realized: human-body data collection → model analysis → guidance output → training-effect feedback. This reduces reliance on manual text input and supports dynamic real-time perception for fitness guidance.

4.3.4. Privacy-protection technology and industrial norm establishment

Federated learning technology should be popularized, which supports model iteration without centrally collecting raw user health data. Health-related information needs data desensitization processing; storage of sensitive data should be minimized and data access permissions should be standardized, so as to lower privacy-leakage risks. Meanwhile, industrial standards for AI fitness products need formulation. Risk-warning settings should become compulsory, service positioning should be clarified, and clear boundaries should be drawn among general fitness popular science, exercise prescriptions and medical rehabilitation suggestions. It must be made clear that AI fitness services cannot replace professional coaches or medical treatment. Content audit workflows need improvement. Rules for liability division over injuries caused by AI fitness products should be gradually clarified, to promote stable and orderly industrial development.

5. Conclusions

Pre-training and fine-tuning constitute the core technical foundation when large language models serve sports-fitness scenarios. Supported by natural-language interaction and multimodal fusion techniques, general-purpose large language models can be adjusted to fit fitness-related vertical tasks. At present, lightweight fine-tuning has become the most widely-adopted technical path for commercial products on the market, and multimodal integration remains the key technical bottleneck to achieve real-time perception of human physical states.

Representative application areas cover fitness-oriented knowledge question-and-answering, personalized exercise prescription generation, AI-powered virtual fitness coaches and sports-related psychological intervention. These applications show clear strengths in delivering personalized outputs, expanding service inclusiveness, simplifying user interaction and supporting follow-up multimodal expansion. Even so, many practical barriers cannot be ignored. Knowledge hallucination, scarcity of domain-specific annotated datasets, insufficient multimodal fusion depth, privacy risks and ambiguous liability rules still restrict large-scale popularization. From a technical

DOI: 10.54254/2755-2721/2026.39081

perspective, major difficulties come from limited high-quality domain data, inherent model hallucination defects, poor multimodal cooperative performance and deployment costs for lightweight models. At the industrial level, unresolved privacy risks, vague liability allocation and inadequate perception of users' real physical conditions further hinder product promotion. Possible solutions include building datasets with expert participation, calibrating model outputs and setting safety guardrails, promoting multimodal technology research, implementing privacy-protection measures and establishing unified industrial norms.

Looking forward, fitness-targeted datasets will keep improving, and multimodal large language models will continue to iterate. Fitness services empowered by large language models are expected to move past simple text-based question-answering, and gradually develop into complete closed-loop intelligent systems that integrate perception, interaction, decision-making and feedback. In technical practice, lightweight vertical fitness models will grow more mature and support edge-side local deployment, which helps balance system response speed and user data privacy. The combination of multimodal tools, motion recognition and physiological monitoring technology will make real-time tracking of training status achievable.

In terms of practical application, AI fitness services may realize finer grouping for different user crowds and provide more secure, tailored guidance for the elderly, people living with chronic illnesses, and groups undergoing sports-injury rehabilitation. It is worth emphasizing that AI fitness tools can only function as auxiliary resources. They are never capable of fully replacing professional offline coaches or clinical sports rehabilitation physicians.

For the whole industry, supporting standards and risk-control mechanisms need continuous improvement. The sector should strike a reasonable balance between technical innovation and sports safety. Only in this way can artificial intelligence better support the national fitness initiative in practice.

References

[1] Song, W., Li, D. Y., Cai, B. Y., et al., (2026). Construction of intelligent question answering system for sports fitness knowledge. *Journal of Capital Institute of Physical Education, 38*(3), 339–352. doi:10.14036/j.cnki.cn11-4513.2026.03.010

[2] Hao, W. B., Pei, Y. J., et al., (2025). Scientific research on sports training based on multimodal data: Comprehensive application of interdisciplinary and large language models. In China Sports Science Association (Ed.), *Summary collection of 2025 national competitive sports science paper Conference - special report*. [publisher unknown], 14. doi:10.26914/c.cnkihy.2025.065798

[3] Wang, R. F., (2025). Research on the reliability of applying large language model to the question answering of sports theoretical knowledge. Henan University. doi:10.27114/d.cnki.ghnau.2025.000334

[4] P, R. P., Saurabh, W., Gaurav, S., et al., (2025). Enhancing personalized fitness: Integrating large language model. *EPJ Web of Conferences, 328*, 01021. doi:10.1051/EPJCONF/202532801021

[5] Zhang, S., Huang, J. J., (2026). The triple positioning and hierarchical approach of big language model in sports health communication. *Journal of Shanghai Sport University, 50*(4), 1–12+28. doi:10.16099/j.sus.2025.04.14.0006

[6] Huang, Y. X., & Wu, B. (2025). Baduanjin new paradigm of intelligent teaching: Research on personalized physical education teaching driven by multimodal large language model. *Sports Vision*, (21), 128–130.

[7] Khasentino, J., Belyaeva, A., Liu, X., et al. (2025). A personal health large language model for sleep and fitness coaching. *Nature Medicine, 31*(10), 1–10. doi:10.1038/S41591-025-03888-0

[8] Sui, Y., Wang, Z. Y., Xu, H., et al. (2024). Application potential evaluation of large language model in exercise prescription formulation. *Exercise and Health, 3*(9), 25–28.

[9] Dergaa, I., Dergaa, A. M., Razzak, M., et al. (2026). Generative artificial intelligence and large language models in sports medicine: A scoping review of applications, accuracy, and ethical implications. *Frontiers in Public Health, 14*, 1843535. doi:10.3389/FPUBH.2026.1843535

[10] Wang, H., Liu, Y., Hu, L., et al. (2026). Applications of natural language processing and large language models in sports injury assessment and rehabilitation decision-making: A scoping review. *Frontiers in Medicine, 13*, 1866874.

DOI: 10.54254/2755-2721/2026.39081

doi:10.3389/FMED.2026.1866874